ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 6 | Issue: 7 | July 2020 || Journal DOI: 10.36713/epra2013 || SJIF Impact Factor: 7.032 ||ISI Value: 1.188

PEA POD FOR COAGULATION OF TURBID WATER

Muhammad Muhammad Makki
University of Bahri,
Khartoum Sudan

Dr. Osama Mohamed Ahmed Adam
Sudan University of Science and Technology,
Khartoum Sudan

Prof. Salih Elhadi Mohamed Ahmed
Sudan University of Science and Technology,
Khartoum Sudan and Bahri University,
Khartoum Sudan

ABSTRACT

Affordable and efficient Natural coagulants are considered substitutes to chemical coagulants for use in developing countries where raw materials such as Cicer arietinum (green pea) are readily available. The research aims to determine the effectiveness of Pea pod extract as coagulants in water treatment. Pea pod powder was prepared, Stock solution of pea pod coagulants of 10% concentration was also prepared, the stock solution was diluted and was used to prepare water samples of high and medium turbidities of high (416 NTU) and medium (162 NTU) and low (40 NTU) turbid waters While the untreated water was collected from Kura Open channel surface water and well water (Underground water) at Zoo road of initial turbidity of (297NTU) and (29NTU) respectively and Jar test procedure for coagulation was conducted for the different water samples. The result The Optimum Dose was 1600mg/L corresponding to the Highest Turbidity Removal Efficiency of High Turbid water, Medium turbid water, Low turbid water, Kura Surface water (96.63, 82.7, 67.5, and 81.5% respectively) and Optimum Dose for Zoo road well water was 1200mg/L at Turbidity removal efficiency of 50%. At optimum doses (1600mg/l for high, medium, low and Kura surface turbid waters and 1200mg/L for Zoo road well water), pH reduced drastically as Turbidity Removal Efficiency increases ranging from 5.5-6.7 the Optimum pH values after treatment were 5.9, 6.1, 6.65, 6.2 and 6.0 respectively which were within the range set by WHO 2018 standard for drinking water i.e. (6.5-8.5). The Optimum Residual turbidities were 14, 28, 13, 55 and 10NTU for Synthetic High Turbid water, Medium turbid water, Low turbid water, Kura Surface water and Zoo road well waters respectively. High Turbid water, Low turbid water and Zoo road well waters were below 25NTU Max. Residual turbidity for Standard Drinking Water Quality WHO (2018).

For Temperature variation with Turbidity removal efficiencies; Turbidity removal initially varies directly with temperature from 0.5°C to 20°C and the maximum turbidity removal from high, medium, low and Kura surface turbid waters of 96.2 %, 82.7 %, 67.5 % and 81.5% were recorded at 30°C for the optimum dose of 1600mg/l respectively and the maximum turbidity removal from Zoo road water of 50% was recorded at 20°C for the optimum dose of 1200mg/L .It was recommended that The mixing and settling time of water treated with Pea pod should be studied to observe their impacts on turbidity removal. Study should be done on pea pod as coagulant aids with alum and other coagulants. Also, research should be done on the efficiency of Pea pod as an adsorbent and heavy metal removal in waste water treatment.

KEYWORDS: ***Pea Pod, Coagulant, Hard Water***

1. INTRODUCTION

In rural and semi-urban communities in developing countries, people living in extreme poverty are presently drinking highly turbid and microbiologically contaminated water as they lack the knowledge of proper drinking water treatment and also cannot afford the high cost of chemical coagulants. Natural coagulants have bright future and are concerned by many researchers because of their abundant source, low price, environment friendly, multifunction, and biodegradable nature in water purification (Madhavi et al., 2013) and (Kawamura, 1991).

Cicer arietinum (green pea) is a legume of the subfamily Faboideae of the flowering plant family (Saha *et al.,* 2014). It is known as gram or Bengal gram or Egyptian pea. Ancient people associated pea with medical uses. It is widely grown in India, Turkey, and Nigeria. It is an annual plant with a life cycle of one year. The immature peas are used for vegetable. Fresh, canned or frozen matured peas are used as dry peas or slit peas. It is starchy, high in fiber, vitamins, minerals, proteins and lutein. Various researches on the nutritional value of pea were

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 6 | Issue: 7 | July 2020 || Journal DOI: 10.36713/epra2013 || SJIF Impact Factor: 7.032 ||ISI Value: 1.188

conducted by a number of researchers including Meenakshi (2015), and on its coagulating characteristics by Marina *et al.*, (2005). In addition, Saha *et al.*, (2014) reported that the presence of bioactive compounds in pea pod is equal to that present in pea cotyledon or seed. As such, this research focuses on the effectiveness of Pea pod extract as coagulants in water treatment.

2. METHODOLOGY

*2.1 PEA (*CICER ARIETINUM*) POD SAMPLES*

Good quality fresh Pod of the Peas will be selected manually and randomly (in accordance with Kwaji *et al.*, (2010) from the market, and will be authenticated from the Department of Botany and dried under room temperature for two weeks.

2.2 PREPARATION OF PEA POD POWDERS AND CRUDE EXTRACTS

The dried leaves were separately grounded to fine powder using domestic blender. The ground powders were then sieved through a 210μm sieve. The extraction was in accordance with Aweng *et al.,* (2012), but was mixed with a different mixer: Crude extracts was prepared by using 500ml of distilled water to 50g of the prepared powder, which was mixed by a British made (RPM=1400, HP=1/86, watt=8.6) stirrer for 60min and left to settle for 20 minutes to make 10% stock solution of the Pea pod extract. The crude extracts were finally filtered through Whatman filter paper. The filtrates were prepared at the time of conducting the tests, since deterioration sets in, with delay (Muyibi *et al.*, 1995). The filtrates were used within 48 hours.

2.3 PREPARATION OF SYNTHETIC WATER

Synthetic raw water was prepared to guarantee the homogeneity of raw water to be used with specific concentrations.

2.4 PREPARATION OF STOCK SOLUTION OF PEA POD

The stock suspension was prepared as described by Chidinand Patil *et al.*, (2015). Ten grams (50g) of bentonite, kaolin was added to 500ml of water and then was allowed to soak for 24 hours that was used as stock solution. The stock solution was diluted and was used to prepare water samples of high and medium turbidities of high (416 NTU) and medium (162 NTU) and low (40 NTU) turbid waters. While the untreated water was collected from Kura Open channel surface water and well water (Underground water) at Zoo road, Kano then tested to have an initial turbidity of (297NTU) and (29NTU) respectively.

2.5 PHYTOCHEMICAL ANALYSES OF PEA POD

Complete proximate standard procedure analyses of the pea seed and pod were done in department of animal science and also in biochemistry department Bayero University Kano.

2.6 TURBIDITY TEST

Coagulation/flocculation test was carried out in 'Jar Test' (with PEF Flocculation Test Unit), using three beakers for a dose. 0.25ml of the Pea pod filtrate was added to 300ml of synthesized water. The mixture was stirred at 95 rpm for 3 min. Thereafter, the beakers were left to rest for 120 min. The procedure was repeated using 0.5, 1.0, 2.0, 3.0, 5.0 and 7.0ml of the filtrate (Karina *et al.*, 2013 and Aweng, 2012).

100ml of the sample was taken from the top of each beaker for the tests using a turbidity meter (SGE-200BS). Coagulation activity was calculated using (BUK Civil Engineering Laboratory Manual for 500L):

Coagulation activity (%) = $\frac{Ts-Tb}{Tb}$x 100 ……………………….Equ. 2

Where:
T_s – Turbidity concentration after treatment (NTU)
T_b – Turbidity concentration of blank (NTU)

JAR TESTS

Jar tests was performed using six paddles PEF Flocculation Test Unit (Serial No. PEF 0031/11). Coagulant doses were used respectively for high, medium and low turbidities. The pH values of the samples were taken using PHS-25 pH meter (Ahamed *et al.*, 2010).

2.7 TEMPERATURE VARIATION WITH TURBIDITY

Jar tests was completed for optimum doses for high turbidity, medium and low turbidity of Pea pod extract at 40, 30, 20, 10, 5 and 0.5°C (Larry *et al.,* 2001) but with slight variation starting from 0°C to 50°C. The procedure for the jar test was stated already in Section above. Gallenkamp water bath and a controlled fridge were used to control temperature (and they were different from instruments used in the referenced method).

2.8 VALIDITY OF RESULTS

Raw water a sample was collected and the above tests were conducted on them for validity in accordance with the procedure outlined above.

STATISTICAL DATA ANALYSIS

The following statistical data analysis software was used in;

1. Microsoft Excel
2. R- Programmer

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 6 | Issue: 7 | July 2020 || Journal DOI: 10.36713/epra2013 || SJIF Impact Factor: 7.032 ||ISI Value: 1.188

3. RESULT AND DISCUSSION

3.1 VARIATION OF DOSE ON TURBIDITY REMOVAL EFFICIENCIES

TABLE 3.1: COMPARISON OF RESIDUAL TURBIDITY (NTU) WITH COAGULANT DOSE IN (MG/L) FOR PEA POD UNSTORED

SOURCE		DOSES (mg/L)						
		Initial Turbidity (NTU)	**400**	**800**	**1200**	**1600**	**2000**	**2400**
		Residual Turbidity (NTU)						
Synthetic Turbid waters (NTU)	High turbid water	416	65	29	25	14	20	23
	Medium turbid water	162	120	59	48	28	36	41
	Low turbid water	40	36	32	20	13	20	25
Kura Open Channel Surface Water (NTU)		297	177	120	80	55	70	90
Zoo road Underground (Well) water (NTU)		20	18	15	10	12	14	15

Synthetic water was prepared at high turbidity (416NTU), medium turbidity (162NTU) and low turbidity (40NTU). Untreated water was collected from Kura Open channel surface water and well water (Underground water) at Zoo road, Kano then tested to have an initial turbidity of (297NTU) and (29NTU) respectively. Figure 3.1 shows the effects of doses on turbidity removal efficiencies for High turbid water, Medium turbid water, Low turbid water, Kura Surface Water and zoo road Underground/Well Water for Pea Pod not stored.

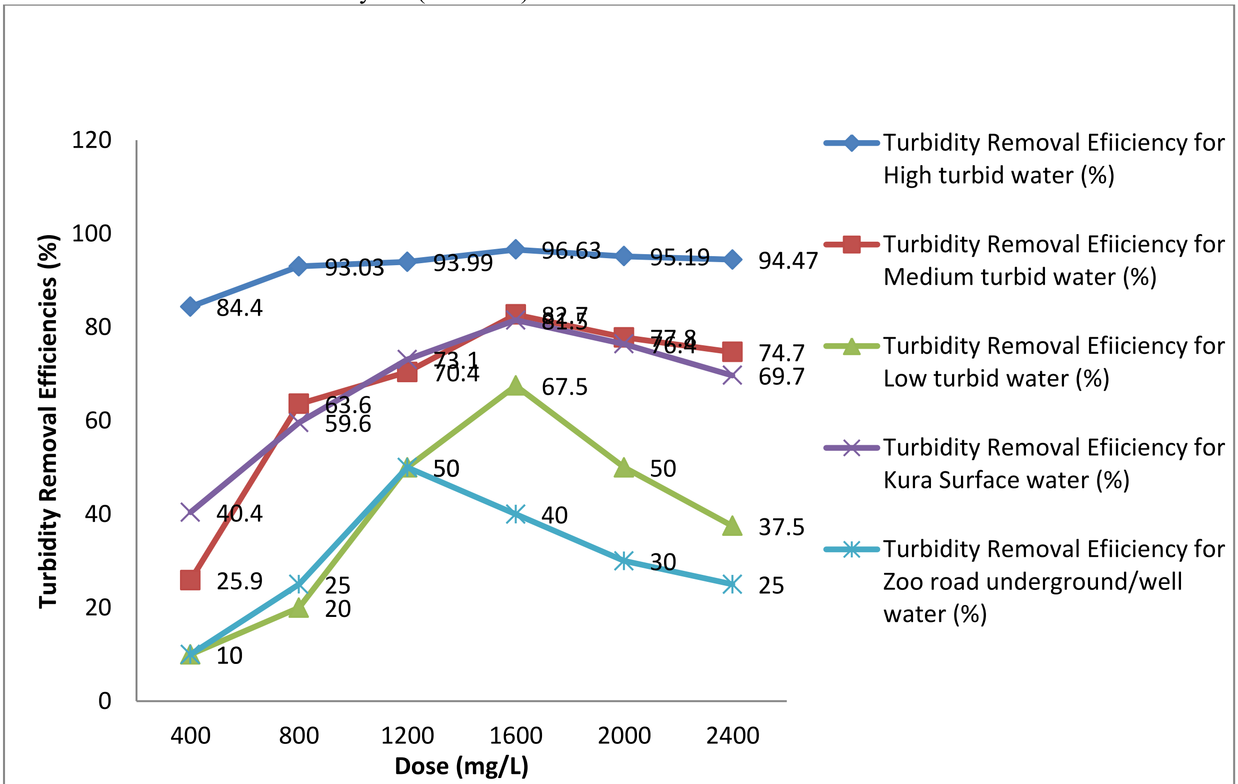

Figure 3.1: The Effects of Doses on Turbidity Removal Efficiencies for Different Water Samples for Pea Pod unstored

From Figure 3.1;

The Turbidity Removal Efficiencies of the water samples; High Turbid water, Medium turbid water, Low turbid water, Kura Surface water and Zoo road well water values started from (84.4-94.47%), (25.90-74.70%), (10-37.5%), (40-69.70%) and (10-25%) respectively for 400-2400mg/L Dose. The Turbidity removal efficiency increases with increase in Dose at the beginning, until it gradually tends to reach its Optimum Dose at 1600mg/L corresponding to the Highest Turbidity Removal Efficiency of High Turbid water, Medium turbid water, Low turbid water, Kura Surface water (96.63, 82.7, 67.5, 81.5% respectively) and Optimum Dose for Zoo road well water was 1200mg/L at Turbidity removal efficiency of 50%. Then the Turbidity removal Efficiencies decreases after optimum doses were reached.

There was, therefore, a notable decrease in turbidity of the synthetic high and medium turbid waters. This can be compared with Pea nut of 92% (Birima *et al.,* 2013), Pea seed of 84.7% and 65.9% (Choubey *et al*., 2012) *Cassia alata* with coagulation activity of 93.33% (Aweng *et al*., 2012), water melon seed of 88% (Muhammad *et al*., 2015), Bosica senegealensis at optimum dose of 50mg/l reduces turbidity from 160NTU to 15-NTU, 23.8 to 2.7NTU for High and Medium Turbid Water respectively (Osama 2001), Cicer arietinum 95.89% (Azfaruzzaman 2011) and *Moringa oleifera* seed extract of 92.99% (Mustapha, 2013)

The fall in the coagulation activity in doses above 1600mg/l for high turbid and medium turbid waters could be attributed to the coagulants that remained in excess of the optimum coagulant dose.

The increase in residual turbidity after the optimum point could also be due to increase in plant chlorophyll concentration in water (Kihampa *et al*., 2011).In that work, turbidity removal, using *Solanum incunum,* was 96, 97 and 75% for raw water with turbidity of 450, 300 and 105 NTU respectively.

For the Kura surface water and Zoo road well water treated separately with Pea pod extract, the coagulants appeared much less effective with, having only 81.5% and 50% Turbidity Removal efficiency at optimum dose respectively. It is worth mentioning that turbidity is caused by chemical, biological or physical factors and its removal depends on the type and size of the impurities present. In fact, Ahamed *et al.,* (2010) emphasized that there were many parameters that affect coagulation performance (and hence turbidity removal) and that include the amount and type of particulate material, the amount and composition of natural organic matter (NOM), and chemical and physical properties of the water. The common parameters are: coagulant type, dose and pH (Yan *et al*., 2008 and Uyak, 2007). Coagulation process is usually dependent on a multitude of factors: initial turbidity, pH-value, composition of water, temperature, intensity and duration of stirring du ring mixing and nature and dose of the coagulant Besides, the coagulation process depends on the extraction mode (Okuda *et al.,* 1999).

Many researches, they said, have shown that natural organic matter reacts or binds with metal ion coagulants and that coagulant dosage is determined by NOM-metal ion interaction and not particle-metal ion interaction (Matilainen *et al*., 2002).

The much difference in effectiveness of the two coagulants in the treatment of synthetic and natural turbid waters could be attributed to these factors. The natural turbid water used (Kura Open Surface channels and Zoo road well water) could have contained NOM and other substances that the coagulants used did not have effect on.

Appendix A, gives the variation of residual turbidities with the doses. It can be observed from the table that, although, the turbidity of the raw water was drastically reduced, the residual turbidity was still higher than 5NTU specified by WHO 2018 standard for Drinking Water Quality.

3.2 EFFECT OF THE PEA POD EXTRACT ON pH OF WATER

The initial pH values of the water samples were 6.7, 6.8, 6.9, 6.7 and 6.9 respectively for high, medium and low, Kura Open Channel Surface Water and Zoo road underground (Well) water turbidities, and the initial pH of the Pea Pod Extract was 3.5.

However, when the high, medium and low, Kura Open Channel Surface Water and Zoo road Underground (Well) waters were treated with various doses of the Pea pod extract, the pH values changed (towards alkalinity) as shown.

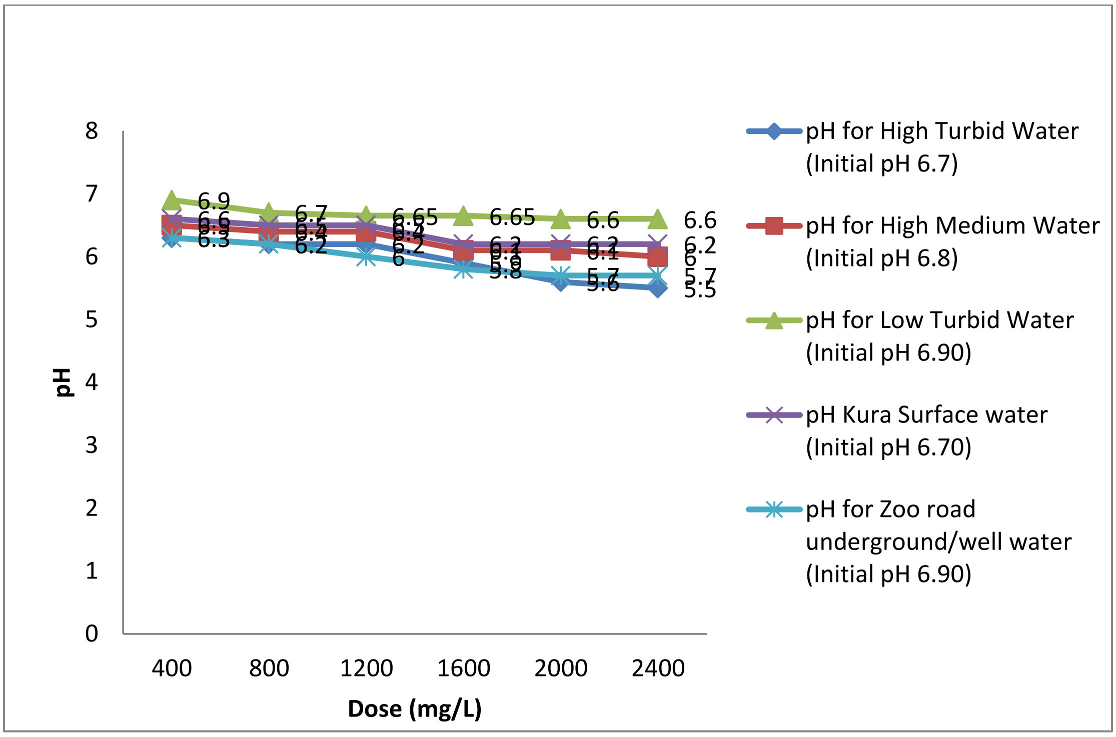

Figure 3.2: The Effects of Doses On pH for Different Water Samples for Pea Pod unstored

At optimum doses (1600mg/l for high, medium, low and Kura surface turbid waters and 1200mg/L for Zoo road well water), the Optimum pH values after treatment were 5.9, 6.1, 6.65, 6.2 and 6.0 respectively.

In a similar research on water treatment, the pH was observed in alkaline nature after treatment with Moringa seed powder, confirmed by the work of Jodi *et al.,* (2012). Musa (2016) in his work discovered a similar pH reduction while treating water with *Poliostigma thonningischum and Tamarinds india L.* leaves extracts. Sethupathy (2015), in his work, discovered a similar pH reduction while treating water with *Moringa oleifera* seed powder. Also Chidanand and Manika (2015) observed pH shift to slightly alkaline nature after treatment with Pea seed powder.

Although the pH of the water varied as a result of the introduction of the plant extracts, it was within the range set by WHO 2018 standard for drinking water i.e. (6.5-8.5).

3.3 EFFECT OF TEMPERATURE ON TURBIDITY REMOVAL

Figure 3.3 shows the variation of Temperature on turbidity removal efficiencies for High, medium, low synthetic turbid water, Kura surface water and Zoo road well water.

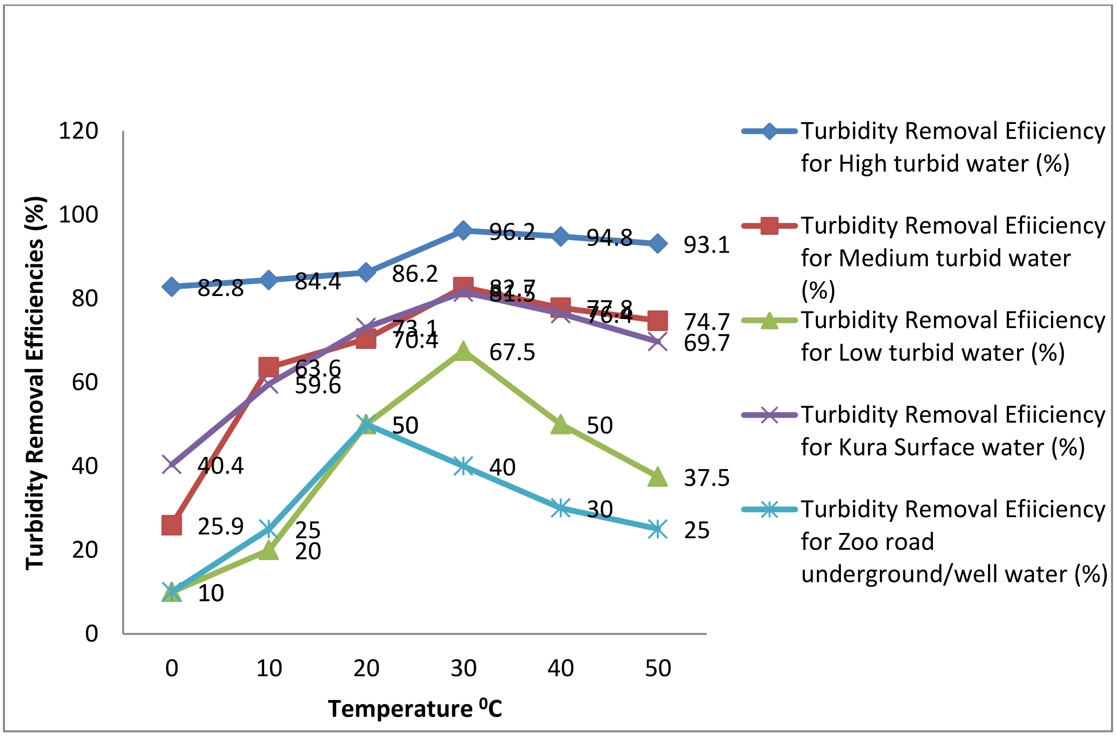

Figure 3.3: Effect of Temperature ⁰C on Turbidity Removal Different Water Samples for Pea pod unstored

Figure 3.3 shows that, turbidity removal initially varies directly with temperature from 0.5°C to 20°C, with some little deviations at 5°C, until it reached maximum at 30°C for high, medium, low and Kura surface turbid waters and 20°C for Zoo road well water. It then began to vary indirectly. The maximum turbidity removal from high, medium, low and Kura surface turbid waters of 96.2 %, 82.7 %, 67.5 % and 81.5% were recorded at 30°C for the optimum dose of 1600mg/l respectively and the maximum turbidity removal from Zoo road water of 50% was recorded at 20°C for the optimum dose of 1200mg/l.

The deviation of the graph at 5°C could be due to anomalous change in density of water as the temperature varied from 0.5°C to 40°C. At temperatures higher than 30°C, the suspended particles in the water might have gained enough kinetic energy to resist the effect of the coagulants, resulting in lesser turbidity removal.

Udaya *et al.,* (2013) revealed almost the same findings that turbidity reduction's best temperature ranges from 20-30 °C.

Also this finding is supported by Madhavi *et al.,* (2013) that turbidity reduction is mostly affected by cold temperatures. Rasha (2014) even argued that low temperatures would impair floc formation because of increased shear stress due to higher water viscosity. According to them, the effect of temperature on the best flocculation time required for efficient sedimentation becomes less when temperature increased to 25°C, and little difference in flocculation times at temperature range from 10 to 25°C, while much higher differences at temperatures less than 10°C.

3.4 VARIATION OF TURBIDITY WITH pH

Figure 3.4 shows the variation of Turbidity Removal Efficiencies with for High, medium, low synthetic turbid water, Kura surface water and Zoo road well water.

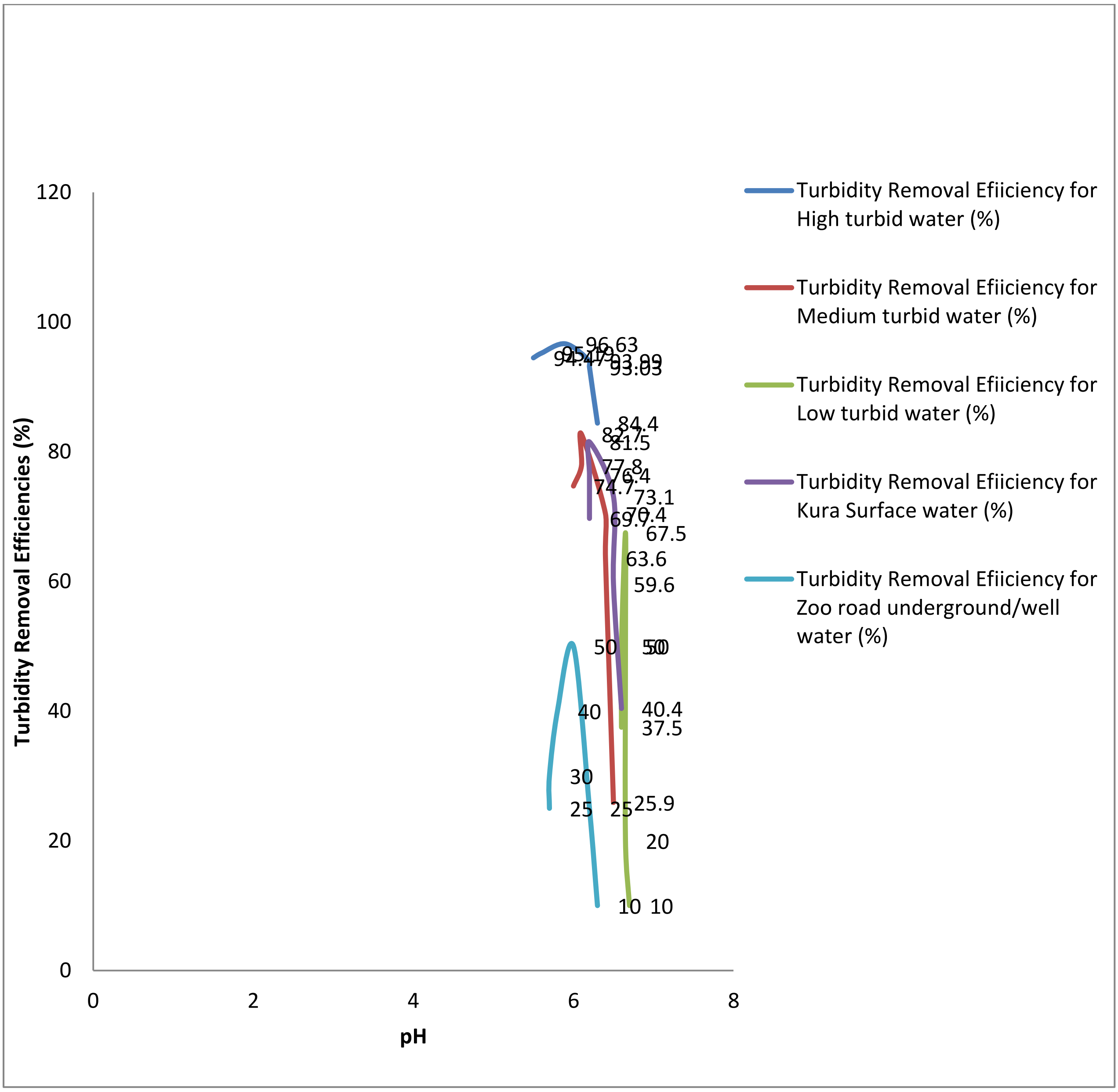

Figure 3.4: The Effects of Turbidity Removal Efficiencies on pH for Different Water Samples for Pea Pod Unstored

It can be seen from Figure 3.4 that pH reduced drastically as Turbidity Removal Efficiency increases ranging from 5.5-6.7. It then changed a bit at optimum dose, and then continues to lower for all the water samples.

A wider difference was observed in pH reduction for synthetic high turbid water sample from 6.3-5.5 compared to that of Medium, low, Kura surface and Zoo road well water samples reductions from pH of 6.6-6, 6.7-6, 6.6-6.2 and 6.3-5.7 respectively, indicating the much impact of Turbidity variation with pH with High Turbid water followed by Low turbid water, Underground water, Medium turbid water and surface water.

Musa (2016) in his work discovered a similar much pH reduction with high turbid water while treating water with *Poliostigma thonningischum and Tamarinds india L.* leaves extracts. Also, Osama (2001) finds much pH reduction with increase in Turbidity removal for high turbid water treated with Bosica senegealensis extract.

Researchers like Udaya *et al.,* (2013), Chidanand *et al.,* (2015) reported similar observations.

Ahamed *et al.,* (2010) in Yan *et al.,* (2008) said that the pH at which coagulation occurs is the most important parameter for proper coagulation performance as it affects the surface charge of colloids, the charge of NOM functional group and the charge of the dissolved phase solubility. They pointed out the need for controlling the pH of high turbid water for effective turbidity removal and found that the best turbidity removal is achieved between pH 5 and 6. They, however, showed that for NOM, higher coagulant doses would be required at higher pH values.

Harashit Kumar Mandal (2014), on his part, argued that there was no direct influence of pH on turbidity, although his research was specific on wastewater.

4. CONCLUSION AND RECOMMENDATION

The Optimum Dose was 1600mg/L corresponding to the Highest Turbidity Removal Efficiency of High Turbid water, Medium turbid water, Low turbid water, Kura Surface water (96.63, 82.7, 67.5, and 81.5% respectively) and Optimum Dose for Zoo road well water was 1200mg/L at Turbidity removal efficiency of 50%.

At optimum doses (1600mg/l for high, medium, low and Kura surface turbid waters and 1200mg/L for Zoo road well water), pH reduced drastically as Turbidity Removal Efficiency increases ranging from 5.5-6.7 the Optimum pH values after treatment were 5.9, 6.1, 6.65, 6.2 and 6.0 respectively which were within the range set by WHO 2018 standard for drinking water i.e. (6.5-8.5). The Optimum Residual turbidities were 14, 28, 13, 55 and 10NTU for Synthetic High Turbid water, Medium turbid water, Low turbid water, Kura Surface water and Zoo road well waters respectively. High Turbid water, Low turbid water and Zoo road well waters were below 25NTU Max. Residual turbidity for Standard drinking water WHO (2018).

For Temperature variation with Turbidity removal efficiencies; Turbidity removal initially varies directly with temperature from 0.5^{o}C to 20^{o}C and the maximum turbidity removal from high, medium, low and Kura surface turbid waters of 96.2 %, 82.7 %, 67.5 % and 81.5% were recorded at 30^{o}C for the optimum dose of 1600mg/l respectively and the maximum turbidity removal from Zoo road water of 50% was recorded at 20^{o}C for the optimum dose of 1200mg/l.

It was recommended that The mixing and settling time of water treated with Pea pod should be studied to observe their impacts on turbidity removal. Study should be done on pea pod as coagulant aids with alum and other coagulants. Also, research should be done on the efficiency of Pea pod as an adsorbent and heavy metal removal in waste water treatment.

REFERENCE

1. *Ahamed F. A., Kamal R. and Mohamed I. G. A. (2010). The effect of pH control on turbidity and NOM removal in conventional water treatment. Fifteenth International Water Technology Conference, IWTC 15 2010, Alexandria, Egypt.*
2. *Asrfuzzaman. Md., A.N.M. Fakhruddin and Md. Alangir Hossain (2011). Reduction of turbidity of water using local available natural coagulants. International Scholarly Research Network ISRN Microbiology Volume 2011, Article ID 632189, 6 pages doi:10.5402/2011/632189*
3. *Aweng, E.R., Anwar, A.I., Siti, R., M.I. and Suhaimi, O. (2012).Cassia alataas a Potential Coagulant in Water Treatment. Research Journal of Recent Sciences, ISSN 2277-2502, Vol. 1(2), 28-33.*
4. *Birima A H, Hammad H A, Desa M N M, Muda Z C (2013). Extraction of natural coagulant from peanut seeds for treatment of turbid water IOP Conf. Series: Earth and Environmental Science 16 (2013) 012065.*
5. *Chadanand Patil and Manika Hugar (2015); Treatment of diary wastewater by natural coagulants. International Research Journal of Engineering and Technology,.*
6. *Choubey Sonal, S.K.Rajput, K.N.Bapat (2012). Comparison of Efficiency of some Natural Coagulants-Bioremediation. International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN 2250-2459, Volume 2, Issue 10, October 2012).*
7. *Harashit Kumar Mandal (2014). Influence of Wastewater pH on Turbidity. International Journal of Environmental Research and Development. ISSN 2249-3131 Volume 4, Number 2 (2014), pp. 105-114.*
8. *Jodi, M. L., Birnin-Yauri, U. A., Yahaya, Y. and Sokoto, M. A. (2012). The use of some plants in water purification. Global Advanced Research Journal of Chemistry and Material Science Vol. 1(4) pp. 071-075, December, 2012.*
9. *Karina, C. V., Leila, C. K. M., Milene, C. B.,Franciele, P. C. and Rosângela, B. (2013). Coagulation diagram using the Moringa oleifera Lam and the aluminium sulphate, aiming the removal of color and turbidity of water. Acta Scientiarum. Technology, 10.4025/actascitechnol.v35i3.12268.*
10. *Kawamura, Susumu (2000-09-14). Integrated Design and Operation of Water Treatment. Facilities. John Wiley & Sons. pp. 74–75. ISBN 9780471350934.*
11. *Kihampa, C., Mwegoha, W.J.S., Kaseva, M.E. and Marobhe, N. (2011). Performance of Solanum incunum Linnaeus as natural coagulant and disinfectant for drinking water. African Journal of Environmental Science and Technology Vol. 5(10), pp. 867-872.*
12. *Kwaji, A., Bassi, P. U., Aoill, M., Nneji, C.M., Ademowo, G. (2010). Preliminary Studies on Piliostigma Thonningii Schum Leaf Extract: Phytochemical Screening and In Vitro Antimalarial Activity. African Journal of Microbiology Research. Vol 4 (9); Pp735-739, 4 May.*
13. *Madhavi, T.P and RajKumar, R. (2013); Utilization of Natural Coagulant for Reduction of Turbidity from Waste Water. International Journal of Chemical Technology Research CODEN (USA): IJCRGG ISSN: 0974-4290. Pp 1119 – 1123.*
14. *Marina B. Sciban, Mile T., Klasnja and Jelena LJ.Stojimirovic "Investigation of the coagulation*

activity of natural coagulants from seeds of different leguminous species" APTEFF, 36, 1-266 (2005).
15. *Matilainen, A., Lindqvist, N., Korhnen, S. and Tuhkanen, T. (2002). Removal of NOM in the different stages of the water treatment process. Environment International. 28 457-465.*
16. *Meenakshi Garg. "Nutritional evaluation and utilization of pea pod powder for preparation of jaggery biscuits" Research article Food and Processing Technology, 2015.*
17. *Muhammad, I.M., Abdulsalam, S., Abdulkarim, A. and Bello, A.A. (2015). Water Melon Seed as a Potential Coagulant for Water Treatment. Global Journal of Researches in Engineering: Chemical Engineering Volume 15 Issue 1 Version 1.0 Year 2015.*
18. *Musa haruna (2016). WATER TREATMENT USING PILIOSTIGMA THONNINGII SCHUM AND TAMARINDUS INDICA L. LEAVES EXTRACTS. Unpublished M.Eng. Thesis, Department of Civil Engineering, Bayero University Kano.*
19. *Mustapha H. B. (2013). A Review of the Applications of Moringa oleifera Seeds Extract in Water Treatment. Civil and Environmental Research ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online) Vol.3, No.8, 2013 Pp 1-10. www.iiste.orgISSN*
20. *Muyibi, S. A. and M. L. Evison: Optimizing physical parameters affecting coagulation of turbid water with Moringa oleifera seeds. Wat. Res. 29, 12 (1995) 2689 – 2695.*
21. *Okuda T, A.U. Baes, W. Nishijima, M. Okuda (1999). Isolation and characterization of coagulant extraction from Moringa oleifera seed by salt solution. Wat. Res. 33, 15 (1999) 3373 – 3378.*
22. *Osama M.A.A. (2001). Influence of Local Coagulants in Water Treatment. Thesis of Master of Science in Environmental Engineering, Sudan University of Science and Technology.*
23. *Rasha Azeez Joudah (2014). Effect of Temperature on Floc Formation Process Efficiency and Subsequent Removal in Sedimentation Process. Journal of Engineering and Development, Vol. 18, No.4, July 2014, ISSN 1813- 7822.*
24. *Saha Haymanti, Alok Prakash, Venkar Kumar S., Manimegalai S. and Deri Rajiswari Rajiswari V. "evaluation of antioxidant activity of Pisum Sativum (pod and grain) and detection of its bioactive compounds by GCMS analysis. "Scholars research library Dear Pharmacia letter, 2014, 6(6); 359-365.*
25. *Sethupathy, A. (2015). An Experimental Investigation of Alum and Moringa Oleifera Seed in Water Treatment. International Journal of Advanced Research (2015), Volume 3, Issue 1, 515-518.*
26. *Udaya Simha L, roopa. S and C. T. Puttaswamy (2013). Investigations of natural coagulants on water quality parameters. International journal of earth science and engineering. ISSN 0974-5904, Volume 06, No. 06(01).*
27. *Uyak, V., Toroz, I. (2007) "Disinfection by-product precursors reduction by various coagulation techniques in Istanbul water supplies" Journal of Hazardous Materials 141 320-328.*
28. *WHO (World Health Organization) (2018). Guidelines for drinking-water quality, WHO water quality, WHO Geneva.*